Gas Plants: *Operational Excellence Or Failure?*

Jack Stout, President and Larry Schavey, Chief Operating Officer

White Paper

Every gas plant has its own history of operational problems that adversely impact unit availability. Media-sensationalized images depicting catastrophic mechanical failures are extreme examples of adverse operational incidents. As an example, the Longford Gas Plant in Victoria, Australia exploded in 1998 when the reboiler on a fractionator failed, releasing a large cloud of hydrocarbon vapors. Several days prior to the incident, the malfunction of an automatic valve forced the use of a manual bypass valve. This, combined with an escalating number of confusing alarms and inadequately trained operators, led to several inappropriate operator actions and slow response.

All of these items contributed to the subsequent explosion. According to Professor Karl Weick, a noted authority on high reliability organizations including hydrocarbon plants from Michigan University, “People often stop and say ‘Where have I seen this problem before?’ When they take the time to think and consult the manuals, the events leading towards failure are continuing to happen. You lose the critical essence of time.”

Ironically, abnormal operations that are historically taken for granted as part of the operations world are almost considered normal. Improvements in Process Safety Management (PSM) initiatives - initially driven by regulatory compliance - form the framework for identifying correct operating procedures. It is believed that in cases like Longford, the use of Operator Training Simulators (OTS) enables plant operations to educate operators and exercise their thought processes with the expectation that they will retain, correctly recall, and properly deploy that information when confronted by such challenges in a real operations scenario (see Figure 1).

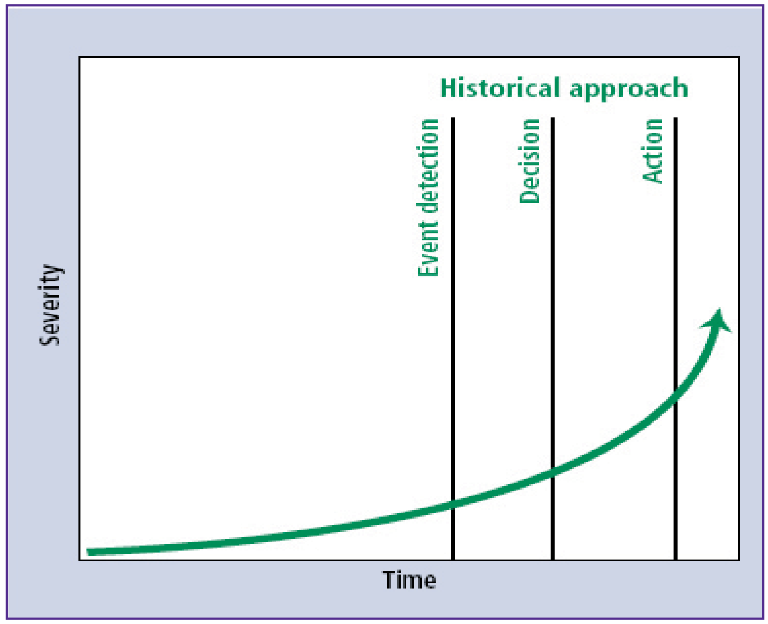

Figure 1 - Historical Approach:
Action not taken until problem becomes more severe

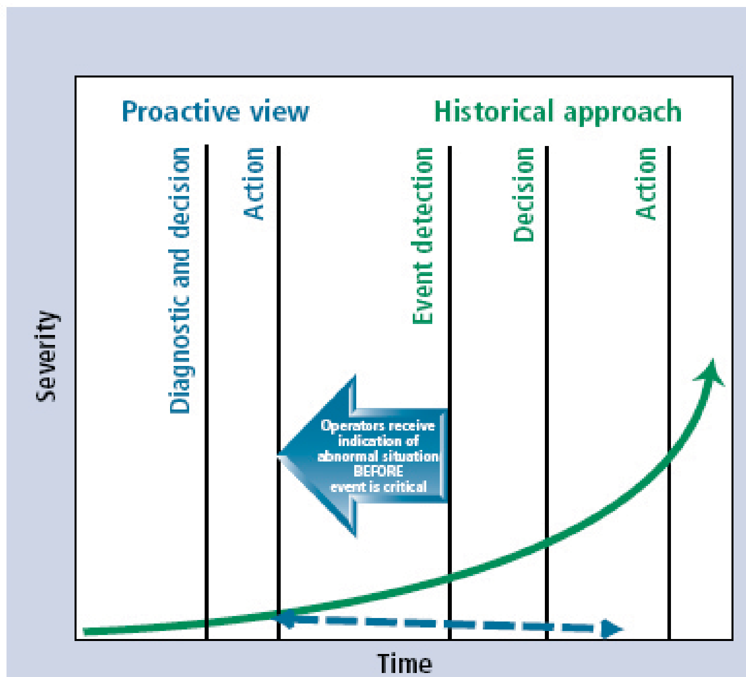

Figure 2 - Proactive Approach:
Early action reduces problem severity

Again Professor Weick challenges this notion by stating, “No matter how much training you do, when a problem occurs, people will be left wondering which training applied to the problem.” He also notes that “in air traffic control rooms, the first thing you must do is forget all of your training.” Although this may be somewhat extreme, it reinforces the point that even with training, constant reinforcement is required. This can only occur with an online OpX (Operations Excellence) solution.

While the spectacular images of catastrophic losses may capture the industry’s attention, the real losses are caused by frequently occurring minor events, which occur on a daily basis and across a much broader scope of the assets. These include, but are not limited to:

- Undetected instrument failures leading to the erroneous control of critical process streams

- An unintentionally blocked-in pump left running during a pump swap, resulting in a blown seal

- Undetected pump and equipment performance degradation during turndown conditions, resulting in future constrained capacity when required for the higher operating rate modes

- Moisture breakthrough into a cold section resulting in icing, hydrates and restricted operations

- And the list goes on…

Operational Excellence (OpX) is defined by the ARC Advisory Group as “Consistently Doing the Right Things Well”. As OpX drives the manufacturing aspects of companies, the requirement of real-time must be added to OpX leading to real-time Operations Excellence. The impact of adding real-time to an OpX solution is a fundamental shift in how improved operations and increased HSEQ (Health, Safety, Environmental & Quality) performance can be achieved.

Improving performance values are created through a real-time Operations Excellence solution focusing on the time horizon “at the moment of” or “immediately preceding” a process transition or upset (see Figure 2). The objective is to provide early detection, diagnostic and decision support to the operations team. This enables the operator to consistently intervene and proactively impact event outcomes, rather than always taking a reactive approach to events that have already occurred. A real world solution exists to assist companies in creating the atmosphere of operations excellence in real-time.

“Digitization” of operations best practices and experiences drives the theory of Operations Excellence. Thus, digitization creates a form of intellectual property for the client that can be managed and redeployed on similar processes with different site personnel and at any other locations (see Figure 3). This managed approach to operations excellence enables any type of gas plant to benefit in real-time from a single location’s demonstrated operations improvements. Instead of an individual lead site defining acceptable best practices, ALL of the company’s sites, regardless of geographic location, contribute to the Operations Excellence goal.

In addition to fundamentally changing the operations approach from reactive to proactive, this solution also changes the way companies address the issues of an aging workforce, personnel turnover and other losses of operations experiences.

A digitization strategy deploys logic from these operations knowledge domains through a real-time logic management system to provide early detection, diagnostics and advisories to operations personnel. Deployment of this digitized knowledge provides the operations team with a baseline of real-time operations excellence with which to manage the process unit performance and deliver availability aspects of reliability strategies. In turn, this provides operations personnel with the opportunity to proactively intervene and minimize process upsets to diminish the impact on process equipment.

A real-time, multi-variant analysis of the process and equipment data provides advisories before the process deviation escalates to control system alarm limits. Early intervention results are validated in the observed reductions in control system alarms, even with rationalized alarm systems. Although alarm rationalization projects reduce the total number of alarms experienced by an operator during a process upset, the single parameter limit-based alarms are still the point of detection for the process condition. The pre-alarm diagnostics of an Operations Excellence tool enables operators to detect, diagnose and act on the disturbance before it triggers alarms on the control system.

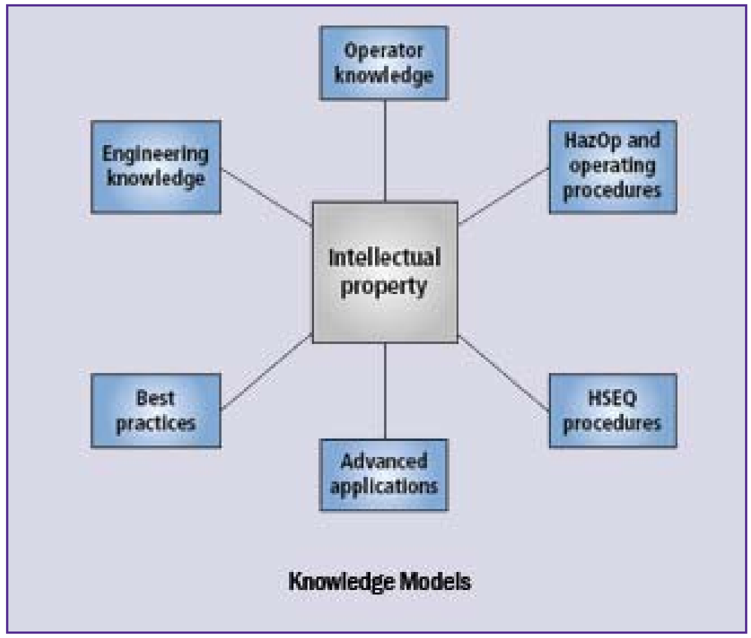

Figure 3 - Digitization creates a form of intellectual property that can be used at several sites.

Application Examples and Benefits

Validation of the information on which the operational control and management decisions are based is the foundation of an OpX solution. Sensor and controller diagnostics provide real-time validation of instrument and control system performance, which enables operations teams to execute with repeatable excellence. The validated information, along with additional diagnostics, drives improvements in advanced applications availabilities and performance. The high maintenance costs resulting from false sensor and controller errors and/or failures contributes to misdirected and often unnecessary maintenance and technical support activities. The benefits of sensor and controller diagnostics alone will typically justify the investment of such a system.

Companies typically have numerous levels of operations models available for their facilities, ranging from models for economic and yield projections to those for properties and mechanical design. Equipment models address the performance of the equipment based on the rules of operations, including the use of transfer functions reflecting the characterization of process properties and dynamics. Specific performance diagnostics around pumps, heat exchangers, fractionators, compressors, etc. found in gas plants provide early detection and diagnosis of operational issues requiring intervention by the plant personnel.

These advanced diagnostics provide benefits specific to the gas plant operational strategies and current performance for that facility. Rules and diagnostics at this level reflect the process troubleshooting and operational responses of many years of experience for new and existing facilities. The digitization and deployment of the technical expertise defined in the initial unit design and PSM processes enables new operations personnel of new or existing units to benefit immediately, in real-time, from the guidance of plant veterans during periods of operational uncertainty. Knowledge models also integrate additional real-time logic into such a program to manage the interaction between multiple pieces of equipment or larger process areas.

OpX theories are applied to gas plant operations in several process areas, ranging from the diagnostics on the inlet gas feed and feed prep areas through the compression and fractionation areas. The diagnostics are based on the progressive levels of the operations complexity and scope of the specific processing technology. OpX provides a framework for the execution of the real-time diagnostics (see Figure 4). The first level of this framework is validating sensor and controller data, which is followed by equipment performance analysis, diagnostics and reporting. More complex process situations are addressed by using standard logic levels in creating knowledge models for process operations across multiple pieces of equipment and process areas. The successful deployment of an OpX system is based on the progressive execution of logic by leveraging the results of the subordinate logic results.

The following application is a specific example of a segment of the overall Gas Plant OpX solution:

Inlet Gas Diagnostics

Although OpX systems can be applied to the wells, platforms and the associated gathering systems, a primary contribution to gas plants is focused on diagnosing inlet feed conditions and advising on the necessary adjustments in plant operations. The primary inlet feed diagnostics are centered on the slug catchers and the initial stabilizer towers. The slug catchers are condensate knockout vessels typically associated with lengthy transmission lines between the offshore platforms and the onshore gas plants. The diagnostics for the slug catcher enable the operators to anticipate a heavy liquids loading as the flow rates and compositions vary with the management of the platforms. The client's models of the fluid dynamics for the line produce the transfer functions for the equipment models to diagnose the impacts of the rate changes, on the onshore facilities. Typical diagnostics consist of:

- Gas Supply rate
- Gas composition changes
- High moisture content/dew point of the gas
- High and low level in each slug catcher
- High and low pressures in each slug catcher
- High CO2 level
- High H2S level

These integrated diagnostics, when proactively presented, enable the operators to anticipate the impacts of rate and composition changes when the long transfer lines introduce dead times in addition to amplifying the impacts of the frequent process changes. These diagnostics are also applied to the stabilizer towers to manage the impacts of the changing conditions.

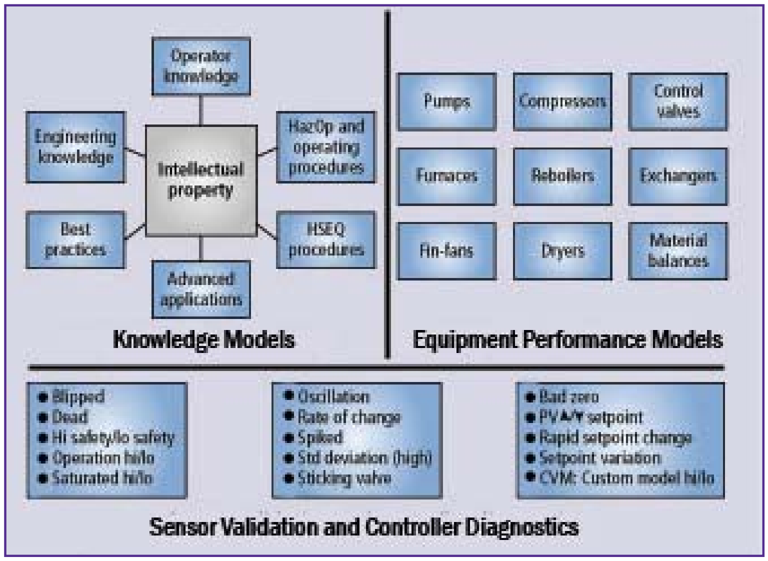

Figure 4 - OpX provides a framework for executing the real-time diagnostics

Benefits

Gas plant benefits are classified into three key areas; production improvement, cost reduction and HSEQ (Health, Safety, Environmental & Quality). Production improvements are the result of increased throughput and improved availability. In gas plant operations, the benefits of availability often have more impact than the incremental gains traditionally targeted by operational improvements. The cost of lost production due to reliability issues is driving gas plant OpX programs to maintain and improve unit availabilities.

The key benefit of OpX programs is improved availability. The early detection and online diagnostics contribute to this improved availability of assets. Improvements in availability result in significant increases in throughput for the gathering systems in addition to the gas plant operations.

Additional production improvements are realized through the reduced costs in chemicals consumption and the more effective use of personnel. In the chemicals area, OpX programs manage the addition of new chemicals (amine, glycol, antifoulants, antifoams, etc.) in addition to minimizing the degradation of the chemicals in the circulating inventories.

An HSEQ focus provides early, consistent, and correct intervention in the process and equipment operations. The personnel supporting manned and unmanned operations benefit by focusing their activities on the pre-diagnosed process and equipment issues detected before they have escalated into process upsets.

As an example, the following economics were identified for the deployment of an OpX program on two gas plant trains totaling 500mscfd including the gathering system.

Gathering system advisory
The gathering system's sensor validation and equipment performance models provide diagnostics on the SCADA system to validate the data and detect problems in the RTU or in the polling of the RTU's.

Gas movement advisory
The gas movement Knowledge Model considers the yield characteristics of each plant and advises the allocation based on the composition profile of the incoming gas.

Demethanizer pressure advisory
This Demethenizer Equipment Performance Model advises the operator on the maximum tower pressure to achieve the targeted liquids recovery. This KM saves approximately 10% of the fuel required by the re-compressors.

Compression advisory
One of the Knowledge Models manages the compressor system. It provides the operator with decision support for various operating scenarios such as; if a compressor goes down, if two compressors go down, how should the operator respond?

Refrigeration system balancing
Another Knowledge Model advises the best balance of the refrigeration load between multiple trains to avoid a refrigeration bottleneck. The increase in ethane recovery was 0.75% across both plants.

Conclusion

The economic impact of OpX solutions is significant in other industries with paybacks typically ranging from 2-5 months. Due to improvements in asset availability and impact on total production, the economics of upstream operations provide scenarios for much shorter paybacks.

The total annual savings identified for this project were $6.9mm on a $500,000 project investment. These savings are typical for OpX programs applied to gas plant and upstream operations.

Although the primary value of an OpX program is delivered through the operator's intervention with the process through the DCS console, the diagnostics provide additional value by providing direction for the maintenance and technical support organizations which may not be located at the site. The SQL database archival of performance diagnostics on the control and instrumentation systems, process equipment and gas plant operations supports the root-cause and performance analysis for Six Sigma quality improvement initiatives. The client's support organizations are able to focus their activities on diagnosed issues versus analyzing historical data for process performance issues or responding to misdiagnosed work order items.

The deployment of new advanced automation technologies to provide the platform for real-time operations excellence enables new and existing gas plant facilities to capture benefits that were previously unavailable. The results are operations excellence instead of operations failure.